

What is claimed is:

- 1 ✓A method of delivering a pressurized glass melt to a glass forming apparatus,  
2 comprising the step of:  
3     a) delivering said glass melt through a molten glass pump, such that an output of  
4         said glass melt is transferred to said glass forming apparatus;  
5         wherein said molten glass pump comprises:  
6             i) a housing having an entrance end for receiving an unpressurized glass  
7                 melt and a distal output end for outputting a pressurized glass melt;  
8                 and  
9             ii) a rotating hub positioned within said housing, said rotating hub  
10                 including a centerline recirculation channel that traverses the length  
11                 of said hub.  
1         2. The method of claim 1, further comprising the step of:  
2             b) uptaking a cord portion of said glass melt at said distal output end through said  
3                 centerline recirculation channel back towards said entrance end.  
1         3. The method of claim 2, further comprising the step of transporting and pressurizing said  
2         glass melt, wherein a plurality of auger flights extending radially from an external  
3         surface of said rotating hub move the molten glass from the inlet end to the distal  
4         end of the pump.  
1         4. The method of claim 2, further comprising the step of:  
2             c) further comprising the step of transporting, pressurizing, and mixing said glass  
3         melt, wherein a plurality of auger flights extending radially from an  
4         external surface of said rotating hub move the molten glass from the inlet  
5         end to the distal end of the pump, include at least one cutout which allow a  
6         portion of said glass melt to pass backwards into another flow path thereby  
7         mixing said glass melt. .

- 1       5. The method of claim 2, wherein multiple sets of blades radially attached to an external  
2                  surface of said rotating hub divide a flow of glass melt exiting a first set of  
3                  adjacent blades as it enters a passageway of a second set of adjacent blades.
- 1       6. The method of claim 2, wherein said molten glass pump further comprises a counter-  
2                  rotating sleeve having a direction of rotation opposite to that of said rotating hub,  
3                  said counter-rotating sleeve surrounding said rotating hub and being disposed  
4                  within said housing with the purpose of eliminating the rotation of the molten glass  
5                  stream exiting the molten glass pump.
- 1       7. The method of claim 6, further comprising the step of uptaking a peripheral portion of  
2                  said glass melt at said distal end of said molten glass pump back towards said  
3                  entrance end through a peripheral recirculation channel lying between said  
4                  counter-rotating sleeve and said housing.
- 1       8. The method of claim 2, wherein said molten glass pump further comprises:  
2                  iii) a first stage including a plurality of auger flights extending radially from an  
3                          external surface of a first-half portion of said rotating hub, wherein said  
4                          auger flights recirculate any poorly homogenized glass that flows off a tip  
5                          of the auger flights back into a fluid stream of glass; and  
6                  iv) a second stage including multiple sets of blades that are radially attached to an  
7                          external surface of a second-half portion of said rotating hub, wherein any  
8                          two adjacent sets of blades are positioned such that a flow of glass melt  
9                          exiting a first set of adjacent blades is divided as it enters a passageway of a  
10                         second set of adjacent blades.
- 1       9. The method of claim 8, wherein said molten glass pump further comprises a counter-  
2                  rotating sleeve having a direction of rotation opposite to that of said rotating hub,  
3                  said counter-rotating sleeve surrounding said rotating hub and being disposed  
4                  within said housing.
- 1       10. The method of claim 9, further comprising the step of uptaking a peripheral portion of  
2                  said glass melt at said distal end of said molten glass pump through a peripheral

3           recirculation channel lying between said counter-rotating sleeve and said housing  
4           back towards said entrance end.

1       11. The method of claim 8, wherein said plurality of auger flights comprise at least one  
2           cutout that a portion of said glass melt to pass backwards into another flow path  
3           thereby mixing said glass melt.

1       12. A glass manufacturing system comprising:

2           a) a glass-melting furnace;

3           b) a fore hearth connected to said furnace;

4           c) a molten glass pump connected to said fore hearth that pressurizes and  
5           homogenizes an unpressurized glass melt into a pressurized glass melt,  
6           wherein said molten glass pump comprises:

7           i) a housing having an entrance end for receiving said unpressurized glass  
8           melt and a distal output end for outputting said pressurized glass  
9           melt; and

10          ii) a rotating hub positioned within said housing, said hub comprising a  
11           centerline recirculation channel that traverses the length of said hub,  
12           wherein said centerline recirculation channel intakes a cord portion  
13           of said glass melt at said distal output end and conducts said cord  
14           portion through said centerline recirculation channel back towards  
15           said entrance end;

16          d) a delivery tube to deliver said pressurized glass melt from said molten glass  
17           pump; and

18          e) a glass-forming device for receiving said pressurized glass melt from said  
19           delivery tube.

1       13. The glass manufacturing system of claim 12, wherein said rotating hub further  
2           comprises a plurality of auger flights extending radially from an external surface of

3       said rotating hub, wherein said auger flights recirculate any poorly homogenized  
4       glass that flows off a tip of the auger flights back into a fluid stream of glass.

1       14. The glass manufacturing system of claim 13, further comprising a counter-rotating  
2       sleeve having a direction of rotation opposite to that of said rotating hub, said  
3       counter-rotating sleeve surrounding said rotating hub and being disposed within  
4       said housing.

1       15. The glass manufacturing system of claim 14, further comprising a peripheral  
2       recirculation channel lying between said counter-rotating sleeve and said housing,  
3       wherein a peripheral portion of said glass melt at said distal end of said molten  
4       glass pump is conducted through the peripheral recirculation channel back towards  
5       said entrance end.

1       16. The glass manufacturing system of claim 12, wherein said rotating hub further  
2       comprises a plurality of auger flights extending radially from an external surface of  
3       said rotating hub, wherein said plurality of auger flights include at least one cutout  
4       that allows a portion of said glass melt to pass backwards into another flow path  
5       thereby mixing said glass melt.

1       17. The glass manufacturing system of claim 16, further comprising a counter-rotating  
2       sleeve having a direction of rotation opposite to that of said rotating hub, said  
3       counter-rotating sleeve surrounding said rotating hub and being disposed within  
4       said housing.

1       18. The glass manufacturing system of claim 17, further comprising a peripheral  
2       recirculation channel lying between said counter-rotating sleeve and said housing,  
3       wherein a peripheral portion of said glass melt at said distal end of said molten  
4       glass pump is conducted through the peripheral recirculation channel back towards  
5       said entrance end.

1       19. The glass manufacturing system of claim 12, wherein said rotating hub further  
2       comprises multiple sets of blades radially attached to an external surface of said  
3       rotating hub, wherein any two adjacent sets of blades are positioned such that a

4           flow of glass melt exiting a first set of adjacent blades is divided as it enters a  
5           passageway of a second set of adjacent blades.

1       20. The glass manufacturing system of claim 19, further comprising a counter-rotating  
2           sleeve having a direction of rotation opposite to that of said rotating hub, said  
3           counter-rotating sleeve surrounding said rotating hub and being disposed within  
4           said housing.

1       21. The glass manufacturing system of claim 20, further comprising a peripheral  
2           recirculation channel lying between said counter-rotating sleeve and said housing,  
3           wherein a peripheral portion of said glass melt at said distal end of said molten  
4           glass pump is conducted through the peripheral recirculation channel back towards  
5           said entrance end.

1       22. The glass manufacturing system of claim 19, wherein said blades are pitched in one  
2           direction.

1       23. The glass manufacturing system of claim 19, wherein said blades have different  
2           lengths.

1       24. The glass manufacturing system of claim 19, wherein said blades are arranged in a  
2           helical pattern around said rotating hub.

1       25. The glass manufacturing system of claim 19, wherein said blades of a first set of  
2           adjacent blades overlap with that of a second set of adjacent blades.

1       26. The glass manufacturing system of claim 19, wherein said blades are pitched in two  
2           directions and at varying pitches..

1       27. The glass manufacturing system of claim 19, wherein said blades are arranged with  
2           varied spacing between said blades.

1       28. The glass manufacturing system of claim 12, further comprising a counter-rotating  
2           sleeve having a direction of rotation opposite to that of said rotating hub, said  
3           counter-rotating sleeve surrounding said rotating hub and being disposed within  
4           said housing.

1       29. The glass manufacturing system of claim 28, further comprising a peripheral  
2       recirculation channel lying between said counter-rotating sleeve and said housing,  
3       wherein a peripheral portion of said glass melt at said distal end of said molten  
4       glass pump is conducted through the peripheral recirculation channel back towards  
5       said entrance end.

1       28. The glass manufacturing system of claim 12, wherein said molten glass pump further  
2       comprises:

- 3           a) a first stage including a plurality of auger flights extending radially from an  
4           external surface of a first-half portion of said rotating hub, wherein said  
5           auger flights recirculate any poorly homogenized glass that flows off a tip  
6           of the auger flights back into a fluid stream of glass; and
- 7           b) a second stage including multiple sets of blades that are radially attached to an  
8           external surface of a second-half portion of said rotating hub, wherein any  
9           two adjacent sets of blades are positioned such that a flow of glass melt  
10          exiting a first set of adjacent blades is divided as it enters a passageway of a  
11          second set of adjacent blades.

1       29. The glass manufacturing system of claim 12, further comprising a counter-rotating  
2       sleeve having a direction of rotation opposite to that of said rotating hub, said  
3       counter-rotating sleeve surrounding said rotating hub and being disposed within  
4       said housing.

1       30. The glass manufacturing system of claim 29, further comprising a peripheral  
2       recirculation channel lying between said counter-rotating sleeve and said housing,  
3       wherein a peripheral portion of said glass melt at said distal end of said molten  
4       glass pump is conducted through the peripheral recirculation channel back towards  
5       said entrance end.

1       31. The glass manufacturing system of claim 28, wherein said plurality of auger flights  
2       comprise at least one cutout that allows a portion of said glass melt to pass  
3       backwards into another flow path thereby mixing said glass melt.

- 1       32. A molten glass pump for pressurizing and homogenizing a glass melt, comprising:
- 2           a) a housing having an entrance end for receiving an unpressurized glass melt and  
3                   a distal output end for outputting a pressurized glass melt; and
- 1           b) a rotating hub positioned within said housing, said hub comprising a centerline  
2                   recirculation channel that traverses the length of said hub, wherein said  
3                   centerline recirculation channel intakes a cord portion of said glass melt at  
4                   said distal output end and conducts said cord portion through said  
5                   centerline recirculation channel back towards said entrance end.
- 1       33. The molten glass pump of claim 32, wherein said rotating hub further comprises a  
2                   plurality of auger flights extending radially from an external surface of said  
3                   rotating hub, wherein said auger flights recirculate any poorly homogenized glass  
4                   that flows off a tip of the auger flights back into a fluid stream of glass.
- 1       34. The molten glass pump of claim 33, further comprising a counter-rotating sleeve  
2                   having a direction of rotation opposite to that of said rotating hub, said counter-  
3                   rotating sleeve surrounding said rotating hub and being disposed within said  
4                   housing.
- 1       35. The molten glass pump of claim 34, further comprising a peripheral recirculation  
2                   channel lying between said counter-rotating sleeve and said housing, wherein a  
3                   peripheral portion of said glass melt at said distal end of said molten glass pump is  
4                   conducted through the peripheral recirculation channel back towards said entrance  
5                   end.
- 1       36. The molten glass pump of claim 32, wherein said rotating hub further comprises a  
2                   plurality of auger flights extending radially from an external surface of said  
3                   rotating hub, said plurality of auger flights including at least one cutout that allows  
4                   a portion of said glass melt to pass backwards into another flow path thereby  
5                   mixing said glass melt.
- 1       37. The molten glass pump of claim 36, further comprising a counter-rotating sleeve  
2                   having a direction of rotation opposite to that of said rotating hub, said counter-

3           rotating sleeve surrounding said rotating hub and being disposed within said  
4           housing.

1       38. The molten glass pump of claim 37, further comprising a peripheral recirculation  
2           channel lying between said counter-rotating sleeve and said housing, wherein a  
3           peripheral portion of said glass melt at said distal end of said molten glass pump is  
4           conducted through the peripheral recirculation channel back towards said entrance  
5           end.

1       39. The molten glass pump of claim 32, wherein said rotating hub further comprises  
2           multiple sets of blades radially attached to an external surface of said rotating hub,  
3           wherein any two adjacent sets of blades are positioned such that a flow of glass  
4           melt exiting a first set of adjacent blades is divided as it enters a passageway of a  
5           second set of adjacent blades.

1       40. The molten glass pump of claim 39, further comprising a counter-rotating sleeve  
2           having a direction of rotation opposite to that of said rotating hub, said counter-  
3           rotating sleeve surrounding said rotating hub and being disposed within said  
4           housing.

1       41. The molten glass pump of claim 40, further comprising a peripheral recirculation  
2           channel lying between said counter-rotating sleeve and said housing, wherein a  
3           peripheral portion of said glass melt at said distal end of said molten glass pump is  
4           conducted through the peripheral recirculation channel back towards said entrance  
5           end.

1       42. The molten glass pump of claim 39, wherein said blades are pitched in one direction.

1       43. The molten glass pump of claim 39, wherein said blades have different lengths.

1       44. The molten glass pump of claim 39, wherein said blades are arranged in a helical  
2           pattern around said rotating hub.

1       45. The molten glass pump of claim 39, wherein said blades of a first set of adjacent  
2           blades overlap with that of a second set of adjacent blades.

1       46. The molten glass pump of claim 39, wherein said blades are pitched in two directions  
2                  and at varying pitches..

1       47. The molten glass pump of claim 39, wherein said blades are arranged with varied  
2                  spacing between said blades.

1       48. The molten glass pump of claim 32, wherein said rotating hub further comprises:

2                  a) a first stage including a plurality of auger flights extending radially from an  
3                          external surface of a first-half portion of said rotating hub, wherein said  
4                          auger flights recirculate any poorly homogenized glass that flows off a tip  
5                          of the auger flights back into a fluid stream of glass; and

6                  b) a second stage including multiple sets of blades that are radially attached to an  
7                          external surface of a second-half portion of said rotating hub, wherein any  
8                          two adjacent sets of blades are positioned such that a flow of glass melt  
9                          exiting a first set of adjacent blades is divided as it enters a passageway of a  
10                         second set of adjacent blades.

1       49. The molten glass pump of claim 32, further comprising a counter-rotating sleeve  
2                  having a direction of rotation opposite to that of said rotating hub, said counter-  
3                  rotating sleeve surrounding said rotating hub and being disposed within said  
4                  housing.

1       50. The molten glass pump of claim 49, further comprising a peripheral recirculation  
2                  channel lying between said counter-rotating sleeve and said housing, wherein a  
3                  peripheral portion of said glass melt at said distal end of said molten glass pump is  
4                  conducted through the peripheral recirculation channel back towards said entrance  
5                  end.

1       51. The molten glass pump of claim 48, wherein said plurality of auger flights comprise at  
2                  least one cutout that allows a portion of said glass melt to pass backwards into  
3                  another flow path thereby mixing said glass melt.